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Measuring the Mechanical Properties of Bicycle Tyres to Help Predict and Minimize Wobble for Enhanced Safety

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1 INTRODUCTION

Wobble, also known as speed wobble or shimmy, and the hazard it can cause to cyclists, is a well-known behavior of some bicycles. It is a relatively high-frequency oscillation, 4–10 Hz, of the front fork and wheel assembly about the steering axis, and it can result in loss of control if left unaddressed.

The importance of tyre mechanical properties, specifically cornering stiffness, to the wobble motion of bicycles has been shown.[1][2] Some tyres can make a bicycle more likely to wobble, while others can make the same bicycle less likely to wobble.

There are only a few facilities in the world, however, capable of measuring these properties of bicycle tyres, and facilities for testing motorcycle and automobile tyres are not designed to work with bicycle wheels and/or are prohibitively expensive to use.

We introduce and characterize an inexpensive, table-top device for measuring the necessary mechanical properties of bicycle tyres.

Figure 1: An image of an early prototype at the University of Wisconsin-Milwaukee.

2 GENERAL DESCRIPTION

This table-top tyre property measuring device features:

- a rigid-slat treadmill that avoids all issues with curvature in the contact patch caused by rotating disks and drums and only needs a flat surface big enough for a bicycle tyre contact patch.
- compatibility with most bicycle hubs and any rim, so a tyre can be tested on any particular wheel and on a variety of wheels.
- the capability of measuring both cornering stiffness and camber stiffness, as well as the associated moments, referred to by some authors as self-aligning and twisting torques.

3 RESULTS

Figures 2 and 3 below show example raw and summary cornering stiffness and camber stiffness data.[3]

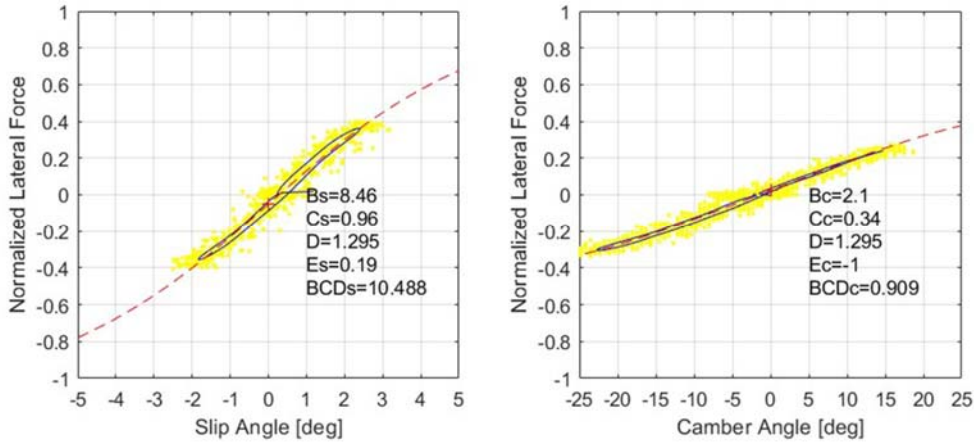

Figure 2: Example stiffness raw data, smoothed line, and fit curves for a particular tyre, rim, vertical load, and inflation pressure.

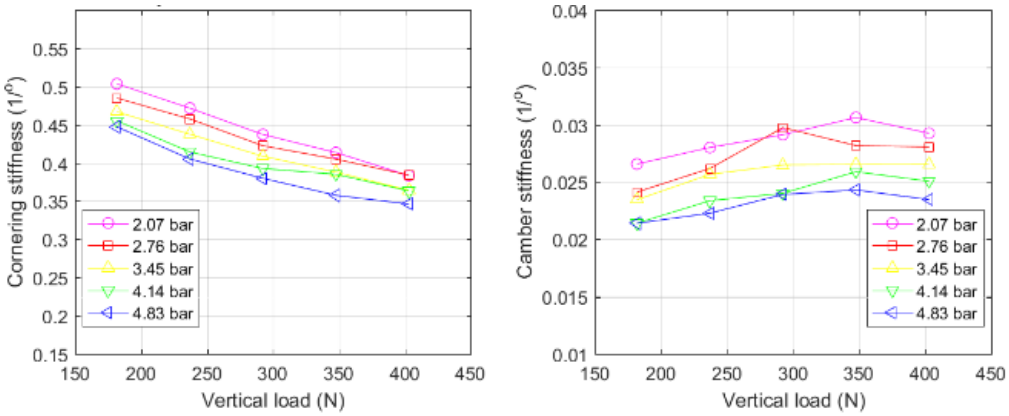

Figure 3: Example summary data showing how stiffness varies with inflation pressure and vertical load.

4 TYRE STIFFNESS EFFECT ON WOBBLE

Sharp's motorcycle equations of motion [4] can be used to show the effect that changes in tyre stiffness can have on the wobble mode if tyres are added to Meijaard's benchmark bicycle [5]. In figure 4, decreasing

Sharp's front tyre stiffness parameter from 628 lb/rad (2793.5 N/rad) to 504 lb/rad (2242 N/rad) causes the wobble mode to become unstable at about 9.5 m/s (34 km/h).

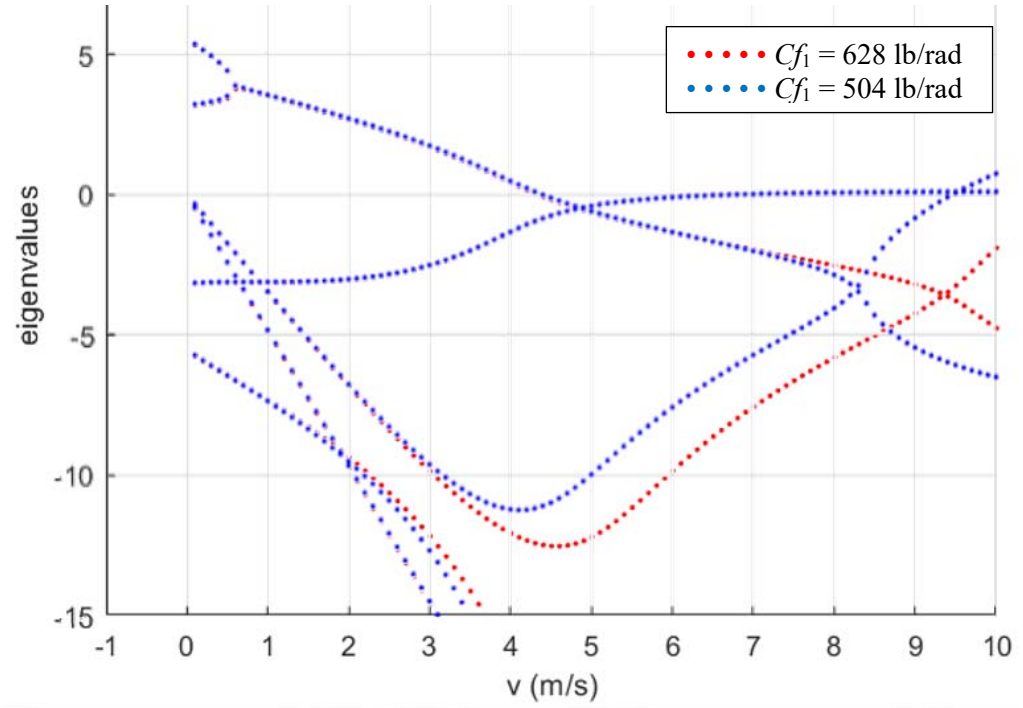

Figure 4: Stability eigenvalues for Meijaard's Benchmark Bicycle with Sharp's motorcycle tyres.

5 EXPECTED RESULTS

We will present the mechanical design features of the new tyre testing machine and how they relate to the resulting accuracy and precision of the tyre stiffness, force, and moment estimates. Cornering and camber stiffness for widely used city bike tyres will be provided and predictions of wobble for consumer bicycles that are known to exhibit the dangerous behavior.

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